

Sanderson Avenue Bridge  
Spanning the Lackawanna River  
on Sanderson Avenue  
Scranton  
Lackawanna County  
Pennsylvania

HAER No. PA-173

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PA  
35-SCRAN  
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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record  
Mid-Atlantic Regional Office  
National Park Service  
U. S. Department of the Interior  
Philadelphia, Pennsylvania 19106

HISTORIC AMERICAN ENGINEERING RECORD

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Sanderson Avenue Bridge

HAER No. PA-173

Location: Spanning the Lackawanna River on Sanderson Avenue,  
Scranton, Lackawanna County, Pennsylvania

UTM: 18.445940.4586990  
Quad: Scranton

Date of Construction: 1904

Designer: Edwin Thacher  
Concrete-Steel Engineering Company  
New York, New York

Builder: Lloyd Collis Contracting Company of New York City

Present Owner: City of Scranton  
340 N. Washington Avenue  
Scranton, Pennsylvania 18503

Present Use: Vehicular and pedestrian bridge

Significance: The Sanderson Avenue Bridge is a single-span reinforced  
concrete-filled spandrel arch structure designed by the  
pioneering engineer Edwin Thacher. It represents an  
early application of reinforced concrete technology  
incorporating several innovative patented design  
features.

Project Information: This documentation was undertaken from May 1989 through  
August 1989 by the city of Scranton and the  
Pennsylvania Department of Transportation (PennDOT) as  
a mitigation measure prior to removal of the bridge/  
  
P.A.C. Spero & Company  
Historic Structures Consultants  
Baltimore, Maryland, for the city of Scranton and  
PennDOT

### THE SANDERSON AVENUE BRIDGE

The Sanderson Avenue Bridge is a single span, reinforced concrete-filled spandrel arch structure built in 1904 and located in the First Ward of the city of Scranton, Pennsylvania. It carries Sanderson Avenue across the Lackawanna River to an intersection with Race Street. It replaced an earlier wooden truss bridge that had linked Race Street and Boulevard Avenue slightly north of the present crossing. This structure was destroyed by flooding in February 1903, and the Common and Select Councils decided to extend Sanderson Avenue across the Lackawanna River to Race Street, rather than reconstruct on the previous location.

Designed by pioneering engineer Edwin Thacher of the Concrete-Steel Engineering Company of New York City, the Sanderson Avenue Bridge is a multi-center arch structure with a span of 110 feet and an overall length of 162 feet. The arch is 13 feet 9 inches, and the roadway is 17 feet above the spring line. It carries two lanes of traffic on a 30-foot roadway; the overall width of the deck is 45 feet, including two 6-foot sidewalks. It is constructed at a 23-degree skew. The bridge has U-shaped concrete wingwalls; the southeast abutment intersects a stone masonry retaining walls, which is incorporated into the foundation of a small brick building. The bridge features minimal Neoclassical decorative detailing, with triangular fielded panels cast into the spandrels, stimulated quoins at the abutments, and a molded cornice. The parapet configuration reflects the structure components, comprising paired concrete end blocks above the wingwalls, linked by an iron railing, 36 feet high. Although much of the original ironwork has been lost, a section of the railing remains intact on the west elevation.

Construction of the Sanderson Avenue Bridge commenced on June 17, 1904. Plans were prepared by the Concrete-Steel Engineering Company of New York City, which had achieved national prominence in the field of reinforced concrete bridge construction. In the decade ending in 1904, this company and its predecessors had constructed some 300 reinforced concrete spans across the country. In a review of the state-of-the-art of reinforced concrete construction in the United States, published in the 1904 Transactions of the American Society of Civil Engineers, Edwin Thacher selected four structures to represent the most notable examples of single-span concrete-steel bridges in the nation; included among these was "a bridge now under construction at Sanderson Avenue, Scranton, Pa." It is likely that Thacher was directly involved in the design of the subject structure. The builder was the Lloyd Collis Contracting Company of New York City. This use of an imported contractor is ironic, in light of Thacher's contention, cited above, that among the benefits of the concrete-steel form was that it could be constructed utilizing local labor and thus retain the funds within the local economy. The New York firm may have offered experience in constructing this unfamiliar, patented design which was not yet available in Scranton.

The Chief Engineer described a setback which occurred during the early stages of construction: "Some difficulty was experienced in excavating for the foundation of the western abutment. At a depth of 4 feet below low water mark, the contractor encountered a wet, sandy clay, which resembled quick sand. After digging a test pit 4 feet below the given elevation for bottom of abutment, a good solid foundation was discovered. Thus, it was decided to make this extra excavation rather than drive piles."

One of the characteristics of reinforced concrete arches, which their detractors emphasized, was the extensive and potentially costly temporary supports and forms which were necessary for their construction. The Sanderson Avenue Bridge required some 100,000 board feet of lumber and timber for its falsework and forming; the falsework was placed on 48 temporary concrete piers.

The skew of the arch required special attention during construction. The standard specifications for concrete-steel arches prepared by the Concrete-Steel Engineering Company directed contractors to place the concrete for skew arches in longitudinal sections at least 5-1/2 feet wide, starting simultaneously from both ends of the arch. Crews were directed to work continuously day and night, if necessary, to complete each longitudinal section. This latter requirement seemed a simple charge in Scranton, which had established its right to be known as "The Electric City" by putting into place one of the nation's first electric street railways in 1886, and boasted 800 electric streetlights in 1904. Electric lights were brought in to enable the work on the Sanderson avenue arch to continue into the night, but this plan was abandoned when the contractor proved unable to obtain workers for the night shift. The construction of the arch took six days. The Chief Engineer reported that no appreciable settlement of the falsework was observed.

Original plans for the Sanderson Avenue Bridge, dated September 29, 1903, clearly indicate the scheme for placement of the "Thacher patent bars" within the structure. The arch ring is reinforced by two longitudinal rows of 1-1/4-inch Thacher bars, one intradosal and one extradosal; covered by 3-inch concrete, each row consists of 45 bars, placed parallel and spaced 12 inches apart. Transverse reinforcement, for distribution and temperature stresses, is located between the rows and consists of vertical Thacher rods 5/8-inch in diameter, spaced 4 feet apart.

The monolithic structure employed a total volume of just under 2,000 cubic yards of concrete, mixed 1:3-1/7:7 in the abutments, 1:3:6 in the spandrels, and 1:2:4 in the arch (cement:sand:aggregate). The specifications required the exclusive use of "established brands of high grade Portland cements which has been successful use under similar conditions to the work proposed for at least three years . . .", Atlas and Alpha brand cements satisfied this condition. A Smith concrete mixer was used, and the mixture was made as wet as practicable; the forms were thoroughly cleansed, oiled, and plastered before the concrete was placed.

The source of the iron railing is unknown. It may have been produced by the Scranton Iron Fence and Manufacturing Company, whose advertisement in the Scranton Times Annual for 1903 illustrated a fence which incorporated design motifs similar to those found on the bridge railing. The original blueprints for the railing show a circular central element within a diamond at each panel, and smaller circles between scrolls at top and bottom; in actual fabrication, however, diamond-shaped forms were substituted for these circles.

Typical of early concrete bridges whose aesthetic effect was deemed important, the vertical surfaces of the Sanderson Avenue Bridge were treated to resemble stone masonry. Moldings attached to the forms created the effect of quoins at the abutments and panels in the spandrels; the face of the arch at the intrados was beveled to correspond. Thatcher devoted considerable space in his 1904 review article to a discussion of various methods of achieving a convincing imitation of masonry, noting that "concrete, as it usually comes from the moulds showing the joints, knots and grain in the casing, has more the appearance of a piece of rough carpenter work than of finished masonry, and some special treatment is necessary." He detailed several experiments involving the application of wooden strips to mold to present the appearance of coursed ashlar, and various ways to reduce the impression of the wood grain from the molds in the finished concrete. Despite the care with which the forms were treated prior to the placement of the concrete, ghost imprints of the planks remain visible on the exterior of the Sanderson Avenue Bridge. It was not until much later in the twentieth century that designers began to allow the fundamental nature of the concrete material to be expressed.

The bridge was complete December 19, 1904, at a total cost of \$24,631.20, including the grading of the northerly approach. The grading of the southerly approach was carried out by contractor V. H. O'Hara at a cost of \$1,325. The cost of property acquisition associated with opening Sanderson Avenue from East Market Street to Race Street was \$10,800.

The construction of the Sanderson Avenue Bridge took place during a period of unprecedented economic prosperity for Scranton. Anthracite coal mining was primarily responsible for Scranton's increasing wealth at the turn of the twentieth century; the city was arguably the center of this industry in the nation, and proud residents magnified its fame to call it the "Anthracite Capital of the World". An important textile industry had also developed in the city by this time, employing the wives of coal miners. Scranton was second only to Philadelphia in textile production in Pennsylvania, which ranked second in that nation in that industry. Numerous other manufacturing and service industries attracted workers and their families to Scranton. The 1900 census revealed that the city's population had doubled since 1880 to exceed 100,000.

The north end of the city was ripe for development at this time. An 1888 atlas shows the area north of the present Sanderson Avenue crossing of the Lackawanna River as largely undeveloped, with the Lackawanna Agricultural Society Fair

Grounds occupying most of the property, bounded on the south by Race Street and on the north by Bates Street. By 1898, this area was owned by J. J. Williams and platted for residential development, but only about a dozen of the 252 planned lots were improved at that time. The area north of Bates Street, known as Finn's Addition, was relatively densely developed by 1898. This development was probably facilitated by the convenient crossing of the Lackawanna River that was in place at Parker Street.

The Sanderson Avenue Bridge undoubtedly funneled part of Scranton's booming population into the area called William's Addition. The city government's aspirations for this new crossing are implied by the Chief Engineer's enthusiastic conclusion, significantly noting the expectation that the new bridge "will open and materially enhance the value of property in the North end of the city and will be a positive boon to those whose business compels them to travel to and fro." These hopes were quickly realized. By 1918, the interior of William's Addition was almost completely built up, with houses lining both sides of Depot and Dean Streets, and filling in the east sides of Brown and Shawnee Avenue. At the north end of the new bridge, the Strand Hotel had been constructed, and the Boston Steam Dye Works has relocated to a new facility, moving from their former location in the small brick building which adjoins the bridge on the southeast.

The importance of this new crossing, in the vision of the City Councils, is suggested by their choice of an esthetically-pleasing structure utilizing a new technology, the employment of a design firm with a nationwide reputation, and the commitment of substantial public funds to its construction (over twice as much as was spent on either of the other Lackawanna River bridges erected that year). The other two bridges which the City Councils ordered to be built across the Lackawanna River in 1904 were of more conventional steel construction. This illustrates an early instance of the competition between the two technologies which began with the introduction of reinforced concrete and continues to the present.

Eighty-five years following its construction, the Sanderson Avenue Bridge was determined structurally inadequate and functionally obsolescent, and was slated for removal and replacement. Demolition of the structure commenced the week of August 14, 1989. The demolition process was monitored to record details of construction and technology which were to be revealed as the structure was dismantled. Removal of the deck surface verified the use of patented Thacher bars, placed as indicated on historic drawings. Significant discoveries included the presence of turnbuckles on the intradosal reinforcing bars, intended to enable adjustment of the bars during construction. In addition, the transverse bars linking the extradosal and intradosal reinforcement were found to be of plain (undeformed) section, and attached to the main bars by means of open-hooked connections. Neither of these details was indicated on the historic drawings nor mentioned in the documentary sources relating to the bridge's construction.

EDWIN THACHER (1840-1920)

Among the American engineers who contributed to the develop of reinforced concrete bridge technology during this formative period was Edwin Thacher. Thacher received a degree in Civil Engineering from Rensselaer Polytechnic Institute in 1863, and began his engineering career on railroads. He worked briefly with the Cedar Rapids and Missouri Railroad in 1863, became Assistant Engineer with the United States Military Railroads from 1864-65, and was Principal Assistant Engineer for the construction of the Cincinnati branch of the Louisville, Cincinnati and Lexington Railroad from 1866-68. He then was employed with the Louisville Bridge Company, where he worked on the mile-long Fourteenth Street Bridge over the Ohio River at Louisville, Kentucky. When this bridge was opened to traffic in 1870, he moved to the Louisville Bridge and Iron Company where he served as Assistant and Computing Engineer until 1879. He then moved to Pittsburgh to become Design Engineer with the Keystone Bridge Company; he was promoted to Chief Engineer in 1883, and held that position until 1887, when he joined the Decatur Bridge and Construction Company at Decatur, Alabama, eventually to become that firm's vice president, general manager, and receiver.

Following the dissolution of the Decatur Bridge and Construction Company in 1888, Thacher returned to Louisville and began a consulting practice which continued until 1894, when he formed a partnership with Keepers and Wynkoop at Detroit, Michigan. Wynkoop dropped out shortly thereafter, and the firm became known as Keepers and Thacher, under which name it worked until 1899.

Thacher became interested in steel-reinforced concrete construction in the late 1880s, and by 1895 had made this a specialty. He designed and constructed viaducts and bridges for leading southern railroads during the period 1889-1904. Also during this period, he became the western representative of Fritz von Emperger's company, and was instrumental in disseminating the Austrian engineer's technological innovations in the United States. In partnership with W. H. Keepers, he designed and constructed the first major reinforced concrete bridge in the United States, a three-span, Melan-type concrete arch with imbedded steel truss bars over the Kansas River at Topeka. Erected between 1894-99, this structure was the largest of its kind at the time.

He became associated with William Mueser in the Concrete-Steel Engineering Company of New York City in 1901, and remained with that firm until failing eyesight compelled his retirement in 1912. Between 1895 and 1912, he had designed some 200 reinforced concrete bridges and had supervised the construction of many of them. His preeminent stature in the design and construction of reinforced concrete bridges was recognized by the American Society of Civil Engineers. In a memoir following his death in 1920, the Society observed that "the greater number of the larger concrete steel bridges that have been built in the United States, up to the present time, have been designed by the concerns in which he was a prominent member".

Among Thacher's numerous patents are designs for a bar-reinforced concrete arch bridge (1899) and a deformed steel bar for structural reinforcement (1902); both of these patents are represented in the Sanderson Avenue Bridge. His design for a concrete arch, filed October 16, 1896, and patented January 10, 1899 (U.S. Patent No. 617,615), shows a concrete arch reinforced by intradosal and extradosal paired metal bars which extend into the abutments at either end. The reinforcing bars were flat with evenly-spaced cylindrical projections on upper and lower surfaces. Thacher described this concrete arch design, which he designated the Thacher system to distinguish it from the reinforcement schemes named for other engineers, as follows:

Steel bars in pairs, spaced at proper distances apart and spliced at convenient intervals, are imbedded in the concrete near the outer and inner surfaces of the arch, and extend well into the abutments or piers. The bars of each pair have no connection with each other, except through the concrete, but each bar is provided with projections, preferably rivet heads of extra height, but which may be lugs, dowels or bolts, spaced at short intervals, thereby providing a mechanical reinforcement of the adhesion between the steel and the concrete, so that a complete crushing or shearing of the concrete must take place before a separation can be effected.

This description corresponds with that of the Sanderson Avenue Bridge in every respect, except that by the time the bridge was constructed, Thacher had developed an improved reinforcing bar. Throughout the development of reinforced concrete technology, engineers sought methods of improving the adhesion between the reinforcing steel and the concrete surrounding it. Their efforts generally involved various deformations to the surface of the bar, such as the "projections" called for in Thacher's 1899 design. Ernest L. Ransome patented the first deformed reinforcing bar in 1884, which aimed to increase the mechanical connection between the steel and the concrete by twisting the bar. Another patent for a deformed bar was granted to A. L. Johnson in 1899, followed in 1902 by Thacher's version. The "Thacher Bar" (U.S. Patent No. 714,971) was designed as an elongated bar with longitudinally oriented, cross-shaped deformations integrally formed on the upper and lower surfaces. This configuration enabled the reinforcing steel to remain uniform in net section throughout the bar, ensuring that the strength of the bar would be the same at every point and that no unnecessary metal would be used in its manufacture. In addition, sharp corners were minimized during manufacture, so that the bond between the bar and the concrete would be further improved. William Mueser, Thacher's associate in the Concrete-Steel Engineering Company, credited the bar as the first product of its type to achieve its final shape by a direct rolling process. The Thacher bar, like those used in current concrete design, was available in a range of sizes, starting at 1/4 inch and increasing in 1/8-inch increments to 2 inches.



Like his fellow proponents of concrete-steel bridges, Thacher cited their inherent beauty, strength, durability, and economy. He extolled the virtues of this technology in an 1899 article in an engineering technical journal:

Concrete-steel bridges, as compared with iron and steel structures, offer the following advantages: they are more beautiful and graceful in design, architectural ornamentation can be applied as sparingly or as lavishly as desired; they have vastly greater durability, and generally greater ultimate economy; they are comparatively free from vibration and noise; they are proof against tornadoes, high water or fire; the cost of maintenance is confined to the pavements, and is no greater than for any other part of the street; home labor is employed in building it, and the greater part of the money that it costs is left among the people who pay for it, and its cost as a rule does not much, if any, exceed that of a steel bridge carrying a pavement.

Henry Jifkin, the Chief Engineer for Scranton, reported that these same considerations shaped the City Councils' decision to construct a concrete-steel bridge across the Lackawanna River at Sanderson Avenue:

The facility with which concrete can be molded to any desired form and its great strength which can be given to such a structure through the use of imbedded steel, and the cheapness of concrete construction, combining in the highest degree the three elements of artistic design, necessary strength and reasonable cost, decided us on the erection of a concrete steel bridge. . . . It is one of the most handsome single span bridges in the State and also one of the strongest. It is practically a monolith with steel imbedded, and no future floods can damage it nor remove it. It requires no repairs, no painting, no future care whatever. Its first cost was its final cost and the City is a great gainer by this addition.

### CONCRETE TECHNOLOGY

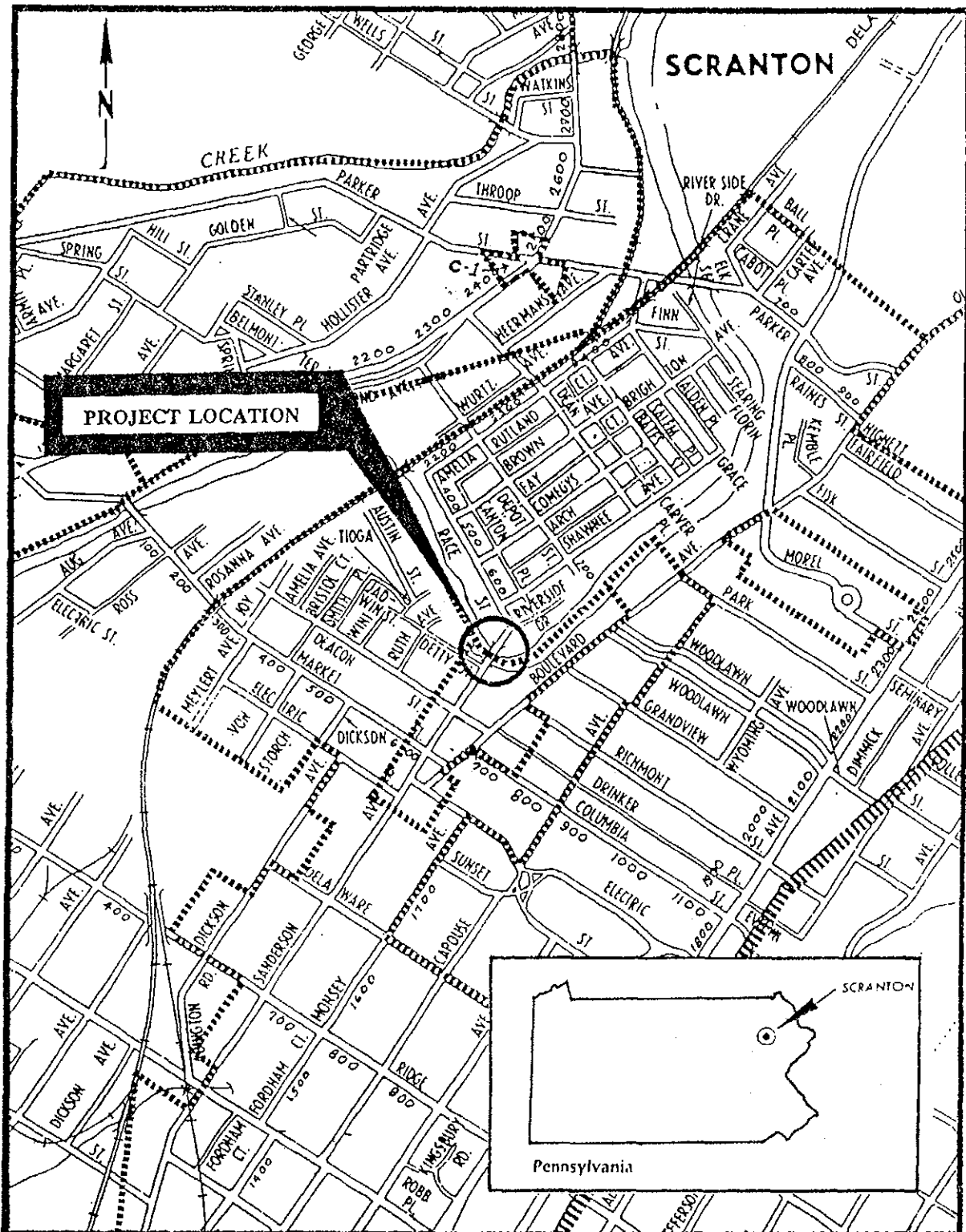
Concrete technology was first applied in bridge construction with plain or non-reinforced concrete structures. An early example in the United States was the 1871 Prospect Park Bridge in Brooklyn, New York. Within two decades, the understanding of material behavior quickly progressed to the composite use of concrete and steel. The addition of iron reinforcement to masonry structures had been used in isolated cases for centuries, as the nature of masonry as a compressive material with inherent weaknesses in tension was appreciated by ancient engineers. The interaction of the two materials remained to be studied by late nineteenth or early twentieth century engineers. The incipient theoretical understanding of metal reinforcement embedded in the new plastic masonry, concrete, seems to have been realized simultaneously in Europe and the

United States. However, French and German engineers first applied the principles of steel reinforcement for tensile stresses in concrete arches in the 1880s. A serious obstacle to the use of concrete arches was the unknown character of their behavior under live loads. From the 1890-95, the Austrian Society of Engineers and Architects conducted extensive experiments on full-size concrete arches and the results were published in engineering journals throughout Europe and America. Thus, the use of reinforced concrete escalated.

The first reinforced concrete arch in the United States was designed by Ernest L. Ransome and built in 1889 in Golden Gate Park in San Francisco. It was reinforced with rods or bars, probably of the twisted type patented by Ransome in 1884. Bar reinforcement became the predominant type in the early twentieth century, and is the reinforcement type encountered today. However, the predominant type, through the end of the nineteenth century, employed I-beams rather than bars. This type was introduced by Austrian engineer Joseph Melan, who patented a scheme for arched I-beam reinforcement in the United States in 1894. His design was modified and patented by another Austrian engineer, Fritz von Emperger, who built a number of beam-reinforced arch bridges in the United States, beginning in 1897.

Beam reinforcement was soon recognized as requiring an inordinate amount of steel, and bar reinforcement began to be explored as a more efficient use of material. Bars could be bent and placed in regions of high tensile stresses. Numerous variations in shapes, deformations, and bending schemes were developed and patented.

Of the three Lackawanna River bridges erected in 1904 to replace structures which had been destroyed by flooding, the Sanderson Avenue Bridge was the only one to utilize the relatively new technology of reinforced concrete, or "concrete-steel," construction. This technology had begun to be applied in Europe in the 1880s, and had won favor among a group of American engineers by the turn of the century. The Sanderson Avenue Bridge represents an early application of this technology to a structure of moderate span in an urban setting.



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